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Response of Phosphorus Levels and Seed Inoculation with PSB and Rhizobium on Economic and Response Studies of Chickpea (*Cicer arietinum* L.) under Rainfed Condition

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A B S T R A C T

A field experiment was conducted at N.D. University of Agriculture and Technology, Kumarganj, Faizabad during the winter seasons of 2008-09 and 2009-10. Application of 60 kg P_2O_5 ha^{-1} was significantly increased almost all the growth, yield attributes and seed yield of chickpea. Seed yield of chickpea was significantly increased 85.46 per cent with 60 kg P_2O_5 ha^{-1} over control. Similar trend in straw yield was also recorded. The plant height, number of branch $plant^{-1}$, number of pods $plant^{-1}$ and test weight was positive and significantly affected by seed inoculation with PSB + Rhizobium. The combined seed inoculation (PSB + Rhizobium) significantly increased the seed yield of chickpea by 20.1 per cent over control. The optimum dose of phosphorus was 61.93 and 61.37 kg ha^{-1} during 2008-09 and 2009-10, respectively. The highest cost of cultivation (Rs. 22613 ha^{-1}), gross returns (Rs. 68425 ha^{-1}), net return (Rs. 45812 ha^{-1}) with 75 kg P_2O_5 ha^{-1} and benefit: cost ratio (Rs. 2.05:1) with 60 kg $P_2O_5ha^{-1}$ and optimum dose of P_2O_5 ha^{-1} was 61.93 and 61.37 respectively

Introduction

Chickpea (*Cicer arietinum* L.) is the most important *rabi* pulse crop of India. Globally chickpea is cultivated on 10.4 million hectares and adding 8.57 million tones to the global food basket with an average productivity of 826 kg ha^{-1}. The chickpea is grown in India on area of 8.81 m ha with production of 7.35 mt (Anonymous, 2009). The primary limitation of crop production in these regions is the lack of available moisture and nutrient especially phosphorus. Among the important nutrients, phosphorus is considered to be most important. In recent years the research work on biofertilizers carried out in different parts of this country indicated the effectiveness of biofertilizers in boosting the production and maintaining the soil fertility. In pulses an extra seed yield of 200-300 kg ha^{-1} and 30-50 kg P_2O_5 ha^{-1} can be saved with the use of phospho-microorganism (Somani, 1990). However, PSB also increase the yield of chickpea by 10 to 30 per cent. Besides, this is the rhizobium legume associated could be fix 50 to 300 kg N ha^{-1} in one crop season.

Hence, an experiment was conducted to study the effect of phosphorus and biofertilizer on growth, yield and quality of chickpea under rainfed condition.

Materials and Methods

A field experiment was conducted during the winter (*rabi*) season for two consecutive years from 2008-09 and 2009-10 at N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P.). The experiment was laid out in balanced confounded asymmetrical RBD design with 3 replications.

The treatment consisted of 6 levels of phosphorus (0, 15, 30, 45 60 and 75 kg P_2O_5 ha^{-1}) and 4 seed inoculants with biofertilizers [uninoculation, phosphate solubilizing bacteria (PSB), Rhizobium and PSB + Rhizobium].

The soil was silt loam in texture and slightly alkaline in reaction pH (8.4 and 8.3), organic carbon (0.30% and 0.31%), available N (175.4 and 152.30 kg ha^{-1}), available phosphorus (15.25 and 16.30 kg ha^{-1}) and available potassium (238.0 and 236.70 kg ha^{-1}).

The chickpea variety "Avrodhi" was sown at the rate of 80 kg seed ha^{-1} in the IIIrd week of October during both the years. The crop received 13.9 and 40.3 mm rainfall during 2008-09 and 2009-10, respectively.

Results and Discussion

Effect of phosphorus

The pooled data revealed that the phosphorus levels significantly affected the yield contributing characters *viz*. pods $plant^{-1}$, number of seed pod^{-1}, seed weight $plant^{-1}$ and test weight and Seed, straw and biological yields of chickpea was increased significantly with increasing level of phosphorus upto 60 kg ha^{-1}. Further increase in level of phosphorus did not increase the seed yield significantly. An increase the seed yield of chickpea 87.46 per cent over control (P_0), 31.80 per cent over 15 kg P_2O_5 ha^{-1} (P_1), 11.32 per cent over 30 kg P_2O_5 ha^{-1} (P_2), 5.33 over 45 kg P_2O_5 ha^{-1} (P_3) and 0.90 per cent over 60 kg P_2O_5 ha^{-1} (P_4).

Similar trend was also observed in biological yield. Mainly increase in all the growth and yield attributes was due to increase in dose of P_2O_5. These findings are in conformity with findings of Meena *et al.,* (2006) reported that the application of phosphorus at the rate of 60 kg P_2O_5 ha^{-1} was significantly enhanced yield and yield components of chickpea.

Response of bio-fertilizers

Seed inoculation with biofertilizer showed significant improvement in yield contributing characters *viz*. Pods $plant^{-1}$, number of seed pod^{-1}, seed weight $plant^{-1}$ and test weight and Seed, straw and biological yields of chickpea.

Combined effect of PSB + Rhizobium seed inoculation recorded significantly higher growth, yield and yield attributes than PSB or Rhizobium inoculation alone. An increase of 15.6 and 19.6 per cent in seed yield was recorded with PSB + Rhizobium over the control, PSB and rhizobium alone. The higher seed yield owing to combined effect of PSB and Rhizobium might be due to better growth and yield attributes (Table 1). The favorable effect of bacterial inoculation could be attributed to the increased supply of the nutrients in inoculation plants resulting into more uptake of nutrients, thereby enhanced the grain and straw yields. The beneficial effect of PSB and Rhizobium inoculation was also reported by Singh *et al.*, (2011) observed significantly higher seed yield of chickpea with rhizobium inoculation than the untreated treatment.

Table.1 Effect of phosphorus level and bio-fertilizer on yield and economic of chickpea (Pooled data)

S.N.	Treatment	Seed Yield (q ha^{-1})	Straw Yield (qha^{-1})	Biological Yield (q ha^{-1})	Protein (%)	Cost of Cultivation (Rs. ha^{-1})	Gross Return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C
a.	**Phosphorus levels (kg ha^{-1})**								
1.	0	13.07	25.18	38.25	18.26	21107	36694	15587	0.74
2.	15	18.56	30.71	49.27	19.36	21492	51892	30400	1.41
3.	30	21.98	33.76	55.73	20.35	21768	61328	39560	1.82
4.	45	23.23	35.77	59.00	21.75	22050	64831	42781	1.94
5.	60	24.24	36.92	61.16	22.59	22332	68096	45764	2.05
6.	75	24.47	37.43	61.90	22.65	22613	68425	45812	2.03
SEm±		**0.28**	**0.37**	**0.54**	**0.26**				
C.D. at 5%		**081**	**1.07**	**1.56**	**0.75**				
b.	**Biofertilizer**								
1.	Uninoculation	18.47	30.47	48.94	19.26	21734	51639	29905	1.37
2.	PSB	20.44	32.42	52.86	20.54	21894	57080	35187	1.60
3.	Rhizobium	21.67	34.14	55.82	21.21	21894	60520	38627	1.75
4.	PSB + Rhizobium	23.12	36.15	59.27	22.27	22054	64937	42884	1.93
SEm ±		**0.23**	**0.31**	**0.44**	**0.21**				
C.D. at 5%		**0.66**	**0.87**	**1.27**	**0.60**				

Values of constants and components

Components	Values	
	2008-09	**2009-10**
A	14.3277	12.4196
B	0.36680	0.349579
C	-0.003	-0.003

Equation for the year 2008-09: $Y= 14.3277+ 0.3668x – 0.003x^2$
Equation for the year 2009-10: $Y= 12.4196+ 0.3495x – 0.003x^2$

Expected seed yield of chickpea at different levels of phosphorus

Phosphorus levels (kg ha^{-1})	2008-09		2009-10	
	Yield obtained (q ha^{-1})	Expected yield (q ha^{-1})	Yield obtained (q ha^{-1})	Expected yield (q ha^{-1})
0	14.01	14.33	12.13	12.42
15	19.60	19.16	17.52	16.98
30	23.20	22.63	20.75	20.21
45	24.43	24.76	22.0	22.07
60	25.62	25.54	23.19	22.53
75	25.83	24.93	23.23	21.75

Most profitable dose of phosphorus

Components	Values 2008-09	Values 2009-10
Maximum yield q ha^{-1}	25.83	23.23
Maximum phosphorus dose kg ha^{-1}	63.24	62.37
Economical optimum dose of phosphorus kg ha^{-1}	61.93	61.37

It is evident from the table that economic optimum dose of phosphorus was 61.93 and 61.37 kg ha^{-1} during 2008-09 and 2009-10, respectively.

Response studies for phosphorus levels

In order to study the relationship between the seed yield of chickpea and various levels of phosphorus, the yield curves were fitted to the yield data of both years.

The equation for quadratic components was fitted to the yield data of both the years as under:-

$$Y = a+bx+cx^2$$

By the use of orthogonal polynomials and the procedure of least squares, the values of the constants and coefficients for the above equation were worked out for the both years of experimentation, which have been given in the following table

Most profitable dose of phosphorus

The optimum dose kg ha^{-1} (X) was worked out by the following equation

$$X = \frac{1}{2c}\left(\frac{p}{q} - b\right)$$

Where

X = Optimum dose kg ha^{-1}

b & c = Constraints measuring curvature of the curve

p = Price of chickpea Rs kg^{-1}

q = Cost of phosphorus Rs kg^{-1}

With the assumption that the response equation was a second degree *i.e.*

$Y= a + bx + cx^2$, the optimum dose of phosphorus was calculated by

$$X = \frac{1}{2c}\left(\frac{p}{q} - b\right)$$

Where p and q represent the price of one kg of chickpea and one kg of phosphorus, respectively.

The average price of chickpea seed was taken Rs. 27.00 and Rs. 27.30 per kg and cost phosphorus was Rs. 20.65 and 20.65 per kg during 2008-09 and 2009-10, respectively.

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